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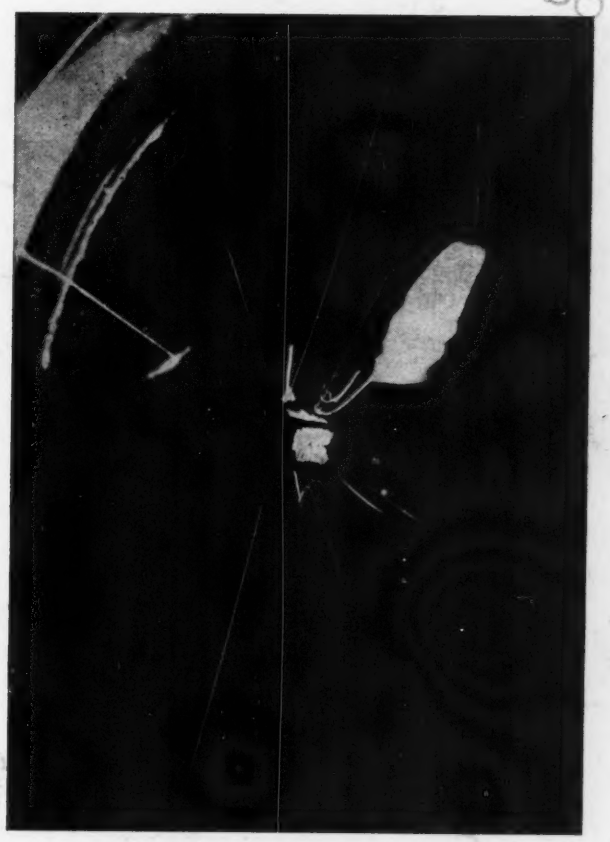

IN THIS ISSUE

Modern Atomic Transmutation

The Bureau of Air Commerce Airplanes

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On the installation shown above, the contractor fabricated by oxy-acetylene cutting and welding the bends, reducers, and other specials in his shop and installed them with tie-in welds on the job. The lines and bends were installed with a proximity which would have been impossible by other methods of joining. The insulation contractor estimated a 30 per cent saving on insulation labor because it was a welded installation.

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THE TECH ENGINEERING NEWS

JANUARY, 1936
VOLUME XVI
NUMBER 7

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Courtesy — *Bell System Technical Journal*

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Published monthly throughout the school year, at Walker Memorial, Cambridge A, Massachusetts, by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer co-operation between Alumni and undergraduates. Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879. Acceptance for mailing at special rates of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920. Copyright 1935 by The Tech Engineering News. Subscription per year $1.50. Foreign $1.75. Single copies 25 cents.

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Technique

FUSION

Research Work in

MODERN ATOMIC TRANSMUTATION

Opens New Fields

By MILTON B. DOBRIN, '36

THERE are few chapters in the history of science which possess a greater interest than the accounts of the medieval alchemists and their long and futile attempts to effect the transmutation of the elements. We have many stories handed down to us of the incessant search made by these pioneers of chemistry for the magical formula by which the baser metals might be transformed into gold and silver. Often these searches were abruptly ended when the unfortunate seeker, unable to make good his rash promises to his duke or emperor, was sentenced to die on the tinseled gallows.

But with the growth of a deeper knowledge of chemistry, it was decided that the elements, by their very natures, were not transmutable one to the other. Indeed, the immutability of the atom was perhaps the most fundamental concept of chemical science in the nineteenth century. An atom of a chemical element was, by definition, indivisible, and the idea of any transmutation was regarded as an obvious impossibility. This conception prevailed until 1896 when Becquerel, by discovering radio activity, proved that the heaviest elements did break down, spontaneously, into lighter ones.

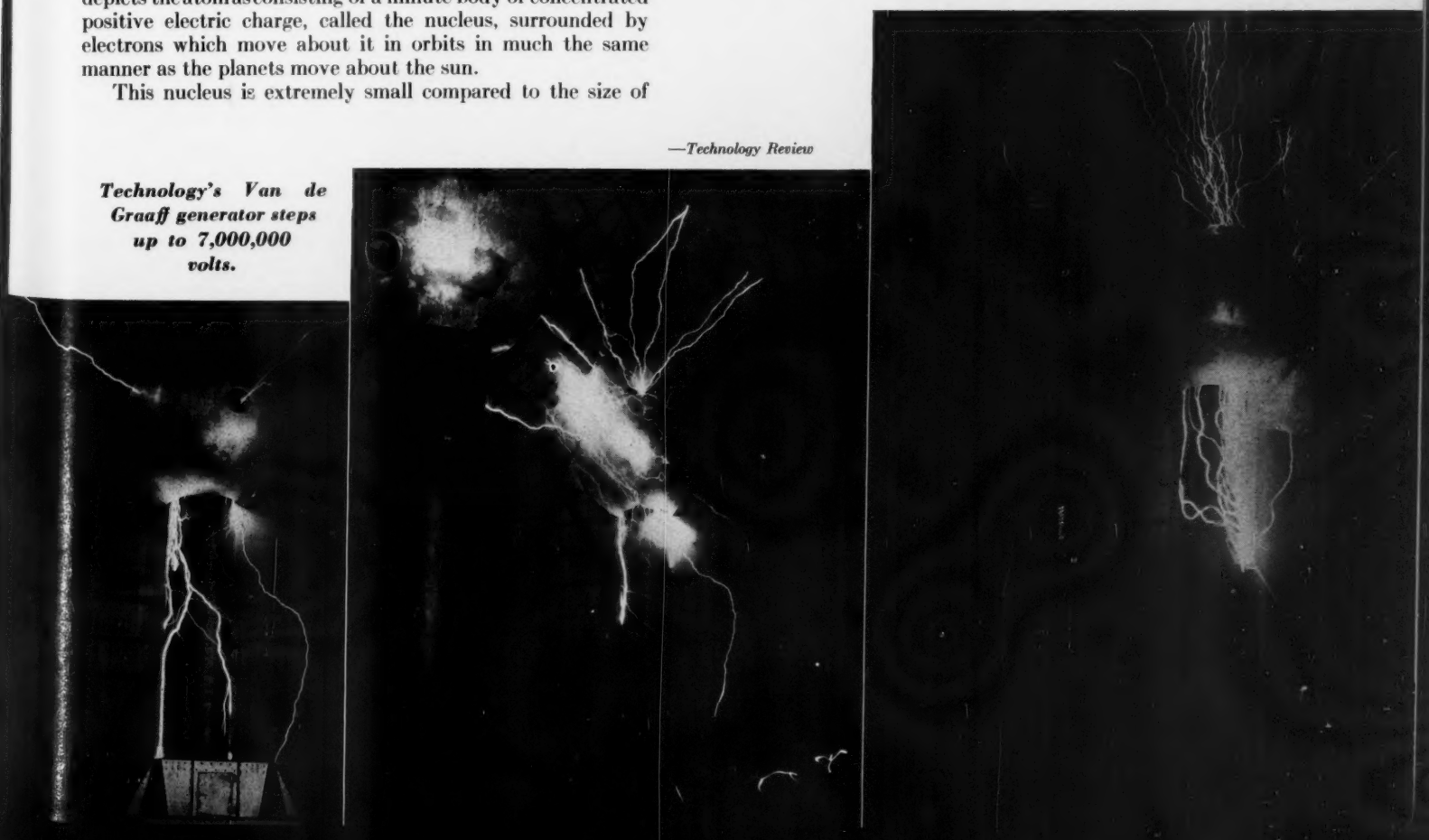
Today, artificial transmutation has become a reality, thanks to the tools of the physicist and the new conception he has given us of the nature of matter. He has reduced the formerly indivisible atom to smaller and more fundamental entities, and he has devised means of shifting these newly-discovered building stones from one element into another. In recent years this work has become one of the major interests of physical science, and there has been no depression of activity in the disintegrating and transforming of elements.

In order to understand just how these transmutations have been achieved, it will be necessary for us to investigate briefly the accepted structure of the atom. The present concept depicts the atom as consisting of a minute body of concentrated positive electric charge, called the nucleus, surrounded by electrons which move about it in orbits in much the same manner as the planets move about the sun.

This nucleus is extremely small compared to the size of the entire atom, but practically all of the weight of the atom is concentrated within it. Up until 1907, it was generally thought that every elementary substance, such as carbon or oxygen, consisted of atoms which were all identical. Then Sir J. J. Thomson built a new weight measuring device, called the mass spectrograph, and proved by it that the atoms of any element are not uniform, but that these elements actually consist of mixtures of several atoms whose weights are integral multiples of the weight of the lightest known atom, hydrogen. Each of these separate species of atom belonging to an element is called an isotope of that element. Thomson's discovery favored Prout's hypothesis, discredited for almost a century, that all atoms are composed of hydrogen atoms.

The nucleus of the hydrogen atom is called a proton. This apparently elementary particle must have a positive charge equal to the negative charge of an electron, for it is known that the hydrogen nucleus has one planetary electron revolving around it and it is also known that the atom as a whole must be electrically neutral. Hence, scientists pictured the nucleus of each atom as consisting of enough protons to account for its mass, and enough electrons to make the atom, as a whole, neutral. However, the discovery of two new elementary particles, as recently as 1932, introduced complications which have altered this picture.

These two building stones are the neutron and positron. The former was predicted by Rutherford in 1920, but it was not actually found until Chadwick proved its existence at the Cavendish Laboratories of Cambridge University in 1932. This particle has practically the same weight as the proton, but unlike the proton it has no electric charge, hence its name. A few months after this discovery, Carl Anderson, a young



—*Technology Review*

Technology's Van de Graaff generator steps up to 7,000,000 volts.

research associate at California Institute of Technology was taking pictures of the tracks left by electrons set into motion by cosmic rays and whirled around by a magnetic field. One day he noticed a track which was twisting around in the wrong direction, as if it were left by a positively rather than negatively charged electron. This particle was called a position, and in the months that followed many confirmations of its discovery were brought about.

According to the present concept, the nucleus consists of protons and neutrons rather than of protons and electrons. The hydrogen atom, mass one unit, consists of a single proton. Heavy hydrogen, the constituent of the heavy water of which we have heard so much recently, has a mass of two units and its nucleus consists of a proton and a neutron. This nucleus, by the way, has been often used as a bombarding projectile to disintegrate other nuclei and it is called a deuteron. The helium nucleus, which consists of two protons and two neutrons in very stable combination, is often called an alpha particle, because it is ejected from many radioactive elements in their disintegration. Lithium, the lightest of the metals, is seen to exist in two forms, or isotopes, one weighing six units, the other, seven. The latter is much more common and we see that it consists of one alpha particle, or helium nucleus, one proton, and two neutrons.

Now physicists have devised means of ascertaining the weights of these elementary particles to a great degree of precision, as well as the weights of the atoms themselves. They have found that the sum of the weights of the particles of which lithium 7 is supposed to be composed comes out to be twelve one thousandths of a unit greater than the known weight of the lithium 7 nucleus. This discrepancy is explained by the fact that matter and energy are interconvertible and that a part of the masses of the constituent particles has gone into the energy necessary to hold them together in the nucleus.

—Technology Review

One terminal of the Van de Graaff generator.

The thick line is a fog track left by a proton produced by disintegrating Aluminum with alpha-particles. The long track concave downwards is the path of a positive electron. The other tracks are left by negative electrons.

This energy of binding, as it is called, explains why atoms are so stable. In order to dislodge a building stone from a nucleus one needs an energy at least equal to this binding energy. It is evident that the only practical way of introducing this energy into the nucleus would be to bombard it with high-speed particles of comparable size, such as protons, neutrons, or alpha-particles.

The energy for the first successful transmutation ever achieved was obtained from a natural, rather than an artificial source. In 1919 Lord Rutherford was observing the effects of alpha-particles, ejected from radium with tremendous energy into an atmosphere of nitrogen. He was able to determine the range of the particles by means of a scintillation screen, a piece of glasscoated with some phosphorescent substance which gives a flash of light each time it is struck by a rapidly moving charged particle. In this case, he observed flashes when the screen was as far as 28 centimeters from the source of alpha particles. Since no alpha-particles had ever been known to travel more than about twelve centimeters in air, Rutherford decided that these new long-range particles must be protons. This would mean that any alpha-particle happening to collide head on with a nitrogen atom — perhaps one in a million — would penetrate the nitrogen nucleus, producing a new nucleus, oxygen^{17} and ejecting a proton, or hydrogen nucleus, according to the equation:

$$N^{14} + He^{4} \longrightarrow O^{17} + H^{1}$$

The first successful bombardment with artificially accelerated particles was carried on by Cockcroft and Walton who disintergated lithium at Cambridge, England, in 1932. Using potentials of several hundred thousand volts, they made high velocity projectiles out of protons, or hydrogen ions, and shot them into a target of lithium metal. On a scintillation screen near the target, they detected a copious stream of alpha-particles. Their appearance could only be explained by assuming that this reaction had taken place:

$$Li^{7} + H^{1} \longrightarrow He^{4} + He^{4},$$

the energy of the proton breaking apart the constituents of the lithium nucleus. By the use of the cloud expansion chamber it was possible to photograph the fog tracks left by the released alpha-particles.

The next important discovery in nuclear physics followed soon after. This was the production of artificial radio activity by the daughter of the late Mme. Curie, Irene Curie, in

collaboration with her husband, M. Joliot. They were bombarding boron with fast alpha particles from radium; and upon removing the radium they noticed that their counting devices kept on clicking, just as if the boron itself were radioactive. This new activity was found to decay just like ordinary radioactivity, but the product of the disintegration was found to be the positive electron, which no naturally radioactive substance had ever been known to liberate in its breakdown. This induced radioactivity was explained by the assumption that the alpha-particle penetrated the boron nucleus, ejecting a neutron but producing an unstable isotype of nitrogen which after a short time would break down into a stable carbon[13] atom and a positron, as indicated by these equations:

$$B^{10} + He^{4} \rightarrow N^{13} + n$$
$$N^{13} \rightarrow C^{13} + \text{positron.}$$

Soon after this, Prof. Enrico Fermi of the University of Rome showed that many artificially radioactive atoms could be formed by bombarding elements with slow neutrons produced by the disintegration of beryllium when struck by alpha-particles. Very recently, E. O. Lawrence at the University of California has obtained a radioactive form of sodium by bombarding the element with high-speed deuterons. This radio-sodium, as he called it, has a half-life of fifteen hours and can be produced in such large quantities that it could be used for medical and biological purposes as a substitute for the more expensive and more dangerous radium.

Today, the nuclear physicist has available every heavy building block of the nucleus as a projectile for the disintegration of atoms. All over the world scientific journals report new transmutations each month. As new sources of high voltage are developed and it thus becomes possible to give these projectiles higher and higher energies, we can expect more and more different types of transmutations and a greater and greater insight into the ultimate constitution of the nucleus.

There are many projects being carried on in various scientific institutions to obtain these high voltages. Lawrence of California, has given bombarding particles energies of over two million volts by whirling them around hundreds of times in a kind of magnetic merry-go-round of most ingenious design. It was with this "cyclatron" that he produced the radio-sodium just mentioned. At Carnegie Institution, Tuve, Hafstead, and Dahl have disintegrated elements successfully with an electrostatic generator operating at 1,300,000 volts. At the Massachusetts Institute of Technology is the biggest of them all, the Van de Graaff generator at Round Hill, which has produced potentials of seven million volts in preliminary tests. It will be put to work at atomic disintegrations as soon as the many experimental difficulties of handling such high voltages are overcome. When it is harnessed successfully we can expect our knowledge of nuclear structure to be extended considerably.

In this study of the vast new field of nuclear chemistry, scientists are led forward by no such objective as the transmutation of the base metals into gold. All the work so far has been on much too small a scale to encourage such a dream. They are induced rather by an insatiable curiosity to learn more about the ultimate constitution of the nucleus and hence of matter itself

Note: This paper was awarded Third Prize in in the 1935 Stratton prize competition.

The high voltage generator at the Massachusetts Institute of Technology Experiment Station at Round Hill, Mass. This is one of the most important instruments in use at the present time for research in the field of nuclear physics.

—Technology Review

An Analysis of the

SCRAP IRON

Export Situation

By PAUL COHEN, '35

WITH a most disconcerting persistence, history has lately been attempting to repeat one of its time worn themes, that of conquest and imperialism. In the West, Mussolini tries to don the mantle of the Caesars but may find the garment uncomfortable in these modern times. In the East there has appeared an island empire which is repeating at a quickened pace the pattern first laid down by the island empire of the West, Great Britain. The policy that "trade follows the flag" has been applied with vigor, as Japan, with grim impartiality, uses Western weapons and Eastern diplomacy in her thrust for industrial and military supremacy in Asia, and Italy tries to conquer the last (except for Liberia) and toughest portion of free Africa.

Unlike England, the islands of Japan are entirely devoid of fuel supplies, either in the shape of coal or oil, and possess only small bodies of poor quality iron ore. Italy faces much the same situation: a dense, energetic population, a country poor in natural resources, and an ambitious government.

The path of a "career" nation is hard. She needs power and raw materials to keep her people busy; she desires a strong military machine to further her prestige and her schemes of trade expansion. And like every other world power in this age of nationalism, she must strive for economic self-sufficiency.

The consequences of these policies are world wide and manifold, but none are more striking than the spectacular and record breaking rise in scrap iron exports from the United States that has occurred in the last few years of business depression.

Illustrative of the conditions which have brought charges that the United States was feeding the munitions factories of the world, which have attracted Congressional attention and barely avoided legislative restriction, which have resulted in a Federal Survey and have destroyed the comfortable obscurity that once veiled this major industry, the scrap iron trade, is the fact that in March of this year, 228,338 tons of scrap iron and steel left American ports to establish an all time peak, an amount slightly greater than all the scrap shipped in 1932.

According to the Department of Commerce, 1,835,554 tons (gross tons of 2240 pounds) of scrap have been sent out of this country in the past year, an eightfold increase over 1932 exports, and over thirteen times the amount shipped in 1931. And the flow continues to increase, for the estimate of R. L. Harding, chief of the iron and steel division of the Department of Commerce, that 1935 may see 2,250,000 tons of scrap shipped, will probably be fulfilled.

That is why the scrap iron industry, from the lowly junk peddler with his ancient nag and wagon, to the broker with his reserves of twenty thousand tons, bask with badly mixed feelings in the glare of unaccustomed publicity. In the teeth of a major depression, scrap again has proven that it is an international commodity, for this material went to Japan, to Poland, to England, to Italy, to China, and in smaller amounts to many other nations.

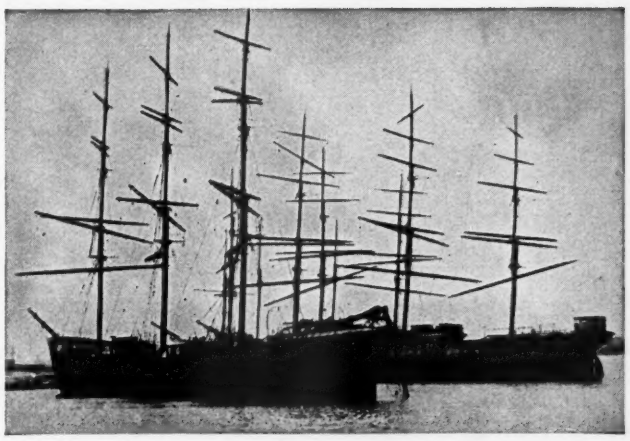
But no unanimous expressions of joy have greeted this windfall to an almost paralyzed industry. Although heavy foreign demand has raised the price of scrap, using No. 1 heavy melting steel as an index, from the record low of $6.42 per ton on July 5, 1932, to the present price of about $11.00 per ton, and has saved many dealers from bankruptcy — the tremendous reserves and low activity of the domestic steel mills having for a time almost closed this market — opponents of exportation claim that if the outward flow of scrap continues at its present unparalleled rate, over three million tons in two years, the United States will be drained dry of a valuable military reserve; potential enemies will arm themselves with our raw materials; domestic steel mills will find it difficult to secure supplies in the face of severe foreign competition.

In the report of the National Resources Board to President Roosevelt, made in January of this year, it is pointed out that the United States is the only important industrial nation that has no regulatory measures concerning the exportation of scrap. Is this a good policy when Japan takes over 63% of the total exports, and Italy, Great Britain, and Poland take the bulk of the remainder? How much of this scrap is being converted into war materials?

Disregarding estimates of 65% made by some American alarmists, an amount conceded to be impossible by steel men, other guesses run from 25% to 10%. Japan claims only 15%

—Ozy-Aclylene Tips

In dismantling this railroad bridge most of the structural shapes were preserved intact by using modern rivet-cutting blowpipe technique.



—*Oxy-Actylene Tips*

One of the last all steel square riggers, "Golden Gate," now consigned to scrap. Yard arms and masts alone represented 350 tons of scrap steel.

of her tonnage goes into armaments, and the opinions of scrap iron dealers, or rather those near salt water, coincide closely. "It is doubtful if 10% finds its way into war materials," says Michael V. Bonomo of the Sciavone-Bonomo Corp., one of the larger eastern exporters. And he points out that foreign steel mills are producing large quantities of rails, beams, channels, and other construction products. How inadequate all such estimates are will be indicated later.

Opposition has already taken concrete form. At the last session of Congress a bill was passed prohibiting the shipment of tin-bearing scrap from this country. It was vetoed by President Roosevelt, but future sessions may see other attempts at regulatory legislation. That agile Congresswoman from California, Florence Kahn, has promised to offer a bill banning the sale to the Japanese of old ships for scrapping.

The latter action arises from the fact that Japanese interests have recently bought some two score obsolete American merchant ships. Most of them were broken up here, but a few moved to Japan under the flag of Nippon, and with a Japanese master on the bridge. Reports from the foreign technical press show that her search is not confined to the United States however, for the Empire of the Rising Sun has bought eighty-six vessels, aggregating 597,000 tons, in the past three years. But Japan can hardly compare with Henry Ford, who, some years ago, bought 199 decommissioned vessels of the American World War fleet for $1,600,000. From Philadelphia he sailed them to his River Rouge plant where they quickly disappeared down the capacious maws of his furnaces, to appear again as shiny new automobiles.

It is the claim of the scrap iron dealers that opposition to exportation arises mostly from the steel mills which fear the rise in price made possible by foreign buying. They would prefer to supply the domestic market, say the dealers, but with that market either comatose or cut off by prohibitive freight rates, they could not but welcome foreign demand.

But not all dealers sing the same song. When a resolution demanding opposition to all possible legislation against exportation was submitted to the 1935 convention of the Institute of Scrap Iron and Steel, the bitter and indecisive battle which followed almost disrupted the meeting. Dealers in the interior have failed to profit from foreign shipments, as freight rates prevented them from getting reasonable prices at salt water ports, and they are therefore a trifle shy in promising to fight objectionable legislation.

In these statistics lies the explanation. Four tons of scrap for export came from Arizona in 1934; 498,224 tons left New York. A ton of steel can be shipped to Japan from New York for $4.00 (9000 miles); a ton of steel can be shipped from New York to Pittsburgh for $5.30 (350 miles). That is why only dealers on the East, Gulf, and Pacific coasts are in a position to patronize the new market.

Nor is the fear that a valuable military and industrial reserve is being drained dry based on indisputable evidence. There is in the United States a huge reservoir consisting of the 750,000,000 tons of steel products in use, the component parts of which wear out and are renewed in cycles varying from about seven years in the case of automobiles to forty years or more in the case of buildings, bridges, and other relatively permanent structures.

Rust will destroy but a small part of the total, the remainder being available for scrap. The estimates of rust losses range from the 16 to 17% stated by Dr. Fr. Frowein at a recent meeting of the Association of German Chemists, to the minimum of 1% set by an article in the *Journal of Commerce*. The reader may make his own guess.

In any case, if domestic steel mills, working at about 40% of capacity, can absorb 15,000,000 tons of scrap in 1934, they need not seriously fear competition with Japan, which with her industry at 100% of capacity, took only 1,200,000 tons of scrap in the same year. It is stated by Mr. R. L. Harding, of the Department of Commerce, that exports of scrap amounted to 18% of the total business last year and gave full time employment to more than 12,000 workers.

But why should Eastern and European nations want American scrap? Fundamentally, there are the cold physical facts that the preparation of one ton of pig iron requires not only 4000 pounds of iron ore, but also 2,200 pounds of coal or coke, 1,200 pounds of limestone, and 9,000 pounds of oxygen. The last item is free for the taking in all countries, of course, but nations are not so happily equipped in regard to the other materials. Supplies of coal and iron ore are practically nil in Italy; Poland can export coal but lacks ore; Japan's situation has already been mentioned. Aside from the question of raw materials, the use of scrap permits certain economies of pig iron and fuel which cannot be attained without it. That is why even here, as much scrap as pig iron is used in charging open hearth furnaces. Electric furnaces use practically 100% scrap.

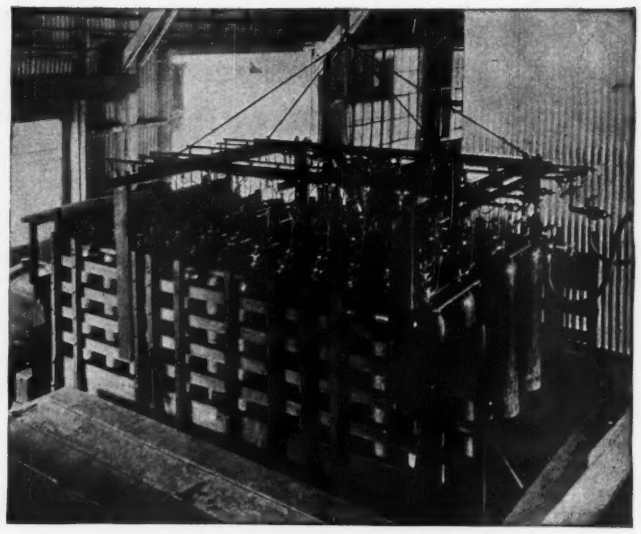
Oxygen and acetylene main distribution lines ready to be laid in trench. Twenty outlets, each complete with shut-off valves assure gas supply to any part of yard.

The tendency in the past decade has been for exports of finished steel to drop and exports of scrap to rise, a natural course when the habits of the importing countries are examined. Since the war, there has been a universal striving towards self sufficiency. Countries lacking essential industries have tried to repair that deficiency, as is borne out by the exports of heavy machinery from the United States and Germany. Only last month, on May 6, the first plant of a sheet steel company was opened at Ansham, Manchukuo. A second plant, costing about 6,000,000 yen, will be completed before the end of the year.

Other and more powerful factors have operated to give Japanese industry its present activity. A recent report by M. S. Farley, research associate of the American Council, Institute of Pacific Relations, indicates that production of iron and steel in Japan has doubled in the last four years, while world production rose only 17%. The depreciation of the yen enabled Japan to maintain her export market, while the rapid industrialization of her new satellite, Manchukuo, to the tune of 430,000,000 yen since 1931, has called for heavy construction contributing to keeping the steel mills at 100% of capacity; in addition, the heavy expenditures for war materials resulting from continuous military action in East Asia has further stimulated her industries.

Another important factor was the depreciation of the American dollar, a sharp stimulus to foreign trade.

The nature of modern warfare makes it impossible to ascertain precisely how much material is going into armaments. To a greater extent than ever before, the tools of peace are the weapons of war. Oil from a Manchukuo refinery may light the lamps of China or pour in black smoke from the funnels of a destroyer. Textile machinery constructed of American cast iron may wave calico for South Sea islanders or clothing for soldiers. The products of a steel mill may easily be used from purely peaceful to entirely warlike purposes. Raw materials and machinery remain the same, as do to a considerable extent, the actual products manufactured.



—*Ozy-Acetylene Tips*

Main oxygen supply for extensive ship scrapping operations mounted on truck for rapid shift in work location.

Congressional attempts to hamper the foreign use of American raw materials will irritate, rather than hinder, nations with which we are at peace. The United States, with her huge natural resources, has long been a supplier of raw materials to less fortunate countries, and it must be remembered that scrap is but a concentrated form of iron ore, coal, and limestone, the exportation of any one of which would in all probability arouse no protest. Contrast the attitude towards scrap with the attitude of American citizens towards cotton, another important war material.

—*Ozy-Acetylene Tips*

Scrapping obsolete war vessels. Profitable large scale scrapping operations depend on efficient organization.

Experiments with

AIRPLANES FOR PRIVATE OWNERS

— *The Economical Airplane*

By JOHN H. GEISSE,
Chief Aeronautics Development Section Bureau of Air Commerce
U. S. Department of Commerce

AMONG the readers of THE TECH ENGINEERING NEWS there probably are some who are airplane pilots, and many others who wish they were, but for various reasons are forced to forego that ambition. They may feel that the cost is too great, that the time required for flight instruction is prohibitive, or that the ability to fly would not be of sufficient utility in their lives the way they plan to live them.

Thousands of persons refrain from flying for these very reasons. With further development of private owner types along lines of simplicity in operation, safety, comfort, and utility, and with reductions in cost, many of them will begin to fly. It is this development that the Bureau of Air Commerce, Department of Commerce seeks to assist with its private-owner-aircraft program.

The art of designing for private owners has not proceeded at a rate comparable with the progress of some other phases of aeronautics because of the fact that funds for development have been limited. In scheduled air transportation, the air lines have had the support of the federal government through air mail contracts, and the provision of air nagivation aids by the Department of Commerce. Their business has expanded rapidly, and they have been able to sponsor design development of air transport types, with highly gratifying results.

Designers of craft for private owners have had to cut their programs to fit sales, and sales have never reached high figures. To increase sales, the manufacturers needed design developments, but they could not get money for design developments except by increasing sales.

To assist the aircraft industry in this dilemma, the Bureau of Air Commerce of the Department of Commerce, about a year and a half ago, established a Development Section to assist in the introduction of new airplane engine and equipment types. The Section's authority is broad enough to embrace all phases of civilian designing, and future projects will include other fields; but thus far emphasis has been placed upon private-owner types because it is there that the need is greatest.

The present program of the Bureau of Air Commerce does not necessarily contemplate the introduction of any one ideal or near-ideal design. It is more reasonable to suppose that the evolution of smaller types will be continued until the various airplanes available really meet the requirements of a number of persons who would like to own and operate airplanes, but cannot undertake to do so under present circumstances. The task which the Bureau of Air Commerce has set for itself is to speed up the process of this evolution, both by encouraging the introduction of specific airplane types, and by helping to develop ideas which may be applied more or less generally.

As to progress thus far made toward that objective, that can best be described by enumerating the projects and giving their status. Five are concerned primarily with airplane design, that is, with simplicity, safety, and comfort of the airplane. Four others have to do with reduction of costs, and specifically with the costs of power plants. Airplane designers have protested repeatedly that the high cost of airplane engines prevents them from undertaking low-priced airplane production, and the Bureau therefore has given close attention to this problem.

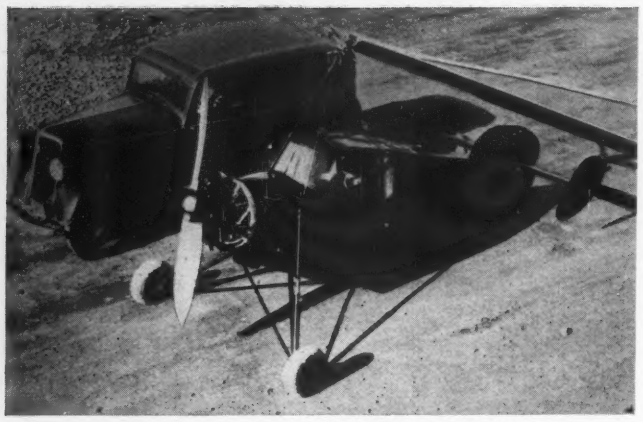
In each case the federal government has contracted with a firm or individual to supply an airplane, an engine, or a propeller of a new type, or to make some specific adaptation of an existing product. Actual development work is done by the industry with the Department in the role of purchaser. In this way the costs of planning and experimenting are borne by the federal government, so that results later can be offered to the public without these development costs included in sales prices.

To start with the airplanes: The first contract signed by the Bureau of Air Commerce, in connection with the development program under discussion, was for the Hammond. This is a pusher type low-wing monoplane with a three-wheel undercarriage calculated to make all landings good landings, and with improved visibility.

The first Hammond, upon reaching the flight test stage, failed to fulfill the expectations of the Bureau of Air Commerce and the contractor. It did not meet specifications with respect to speed and climb, and therefore the design had to go back to the drafting board accompanied by the test pilot's

—National Aeronautic Magazine

An artist's conception of the new wingless Pitcairn Autogiro now under construction.



—*National Aeronautic Magazine*

The "mock-up" of the Pitcairn wingless autogiro, built to test its new direct-control features.

notes and comments.

Particular features sought in framing specifications, under which the Hammond was built, were comfort and safety. These were built into the Hammond. It was provided with a body having the comfort and visibility of an automobile. The three-wheel landing gear, with fixed wheels back of the center of gravity, prevents the airplane from nosing over in a fast landing and eliminates ground looping. In these special characteristics the Hammond proved satisfactory — its failings are in standard items of performance and the contractor has been engaged in locating the "bugs" and getting rid of them. The redesigned Hammond is nearly ready for delivery.

In fairness to all concerned it is necessary to point out that an airplane of a new design is more likely than not to go back to the designing engineers for changes, or even for redesigning as in the case of the Hammond, when the first flight tests have been completed.

The second contract was with Waldo Waterman of Santa Monica, California, for a tailless airplane designed by him. The writer went to California last summer to accept the Arrowplane from Mr. Waterman and flew the craft to Washington.

The Waterman airplane, in its present condition which must be termed experimental, is not exactly fool-proof, but is very close to being so. In the condition in which it was flown from the West Coast, the airplane could not be stalled or spun by any normal or reasonably abnormal use or abuse of the controls.

Due primarily to the type of landing gear used on this airplane, a safe margin of landing speed above stalling speed is perfectly feasible. With this type of landing gear, landings can be made at the minimum speed up to a speed of 80 m.p.h., without danger, and the brakes can be immediately applied. If it is desired to do so, the airplane can be glided straight into a landing without any flaring near the ground which removes entirely the need of any accurate judgment of height above the ground. In other words, it is practically impossible to get into trouble on landing except by actually running into an obstacle. The visibility of the airplane is excellent, and except in rough air only the rudder need be used to hold to the desired course. Turns can also be made using only the rudder.

In its present condition the airplane cruises at 90 m.p.h., has a satisfactory climb, and a ceiling in excess of 12,000 feet.

The tailless feature of the airplane offers possibilities of reduction in production costs, and also reduces the hangar space required. By putting the plane into a hangar wing first, or sidewise, a hangar of about 22-foot span can be used. As hanger construction costs mount rapidly with increase in span, this is an important consideration. In the event that roadable airplane bodies are found practicable, the tailless feature will have an added advantage as only the wings will have to be removed.

A wingless direct-control autogiro has been ordered from the Autogiro Company of America, Willow Grove, Pennsylvania, with safety, comfort and utility as the objectives. The autogiro has an enviable safety record, and the direct-control feature is expected to enhance safety and make control easier. A control column extending downward from the rotor hub is used to exercise lateral, longitudinal, and directional control through tilting of the rotor sideways of fore-and-aft.

The Bureau has specified that its autogiro shall be equipped for operation on the highway, which will be accomplished by providing a drive for the rear wheel. With the rotor blades folded back, an autogiro of this type can be kept in a garage at one's home and then when it is to be flown, driven down the road to the field from which the pilot expects to take off. For an autogiro this may not even be an airport since this craft does not need much space for taking off and landing. In a recent demonstration of this type of autogiro at Philadelphia, the plane was successfully landed and flown from the roof of the new post office.

The Bureau's autogiro is due for delivery in February, and the work on it is progressing satisfactorily.

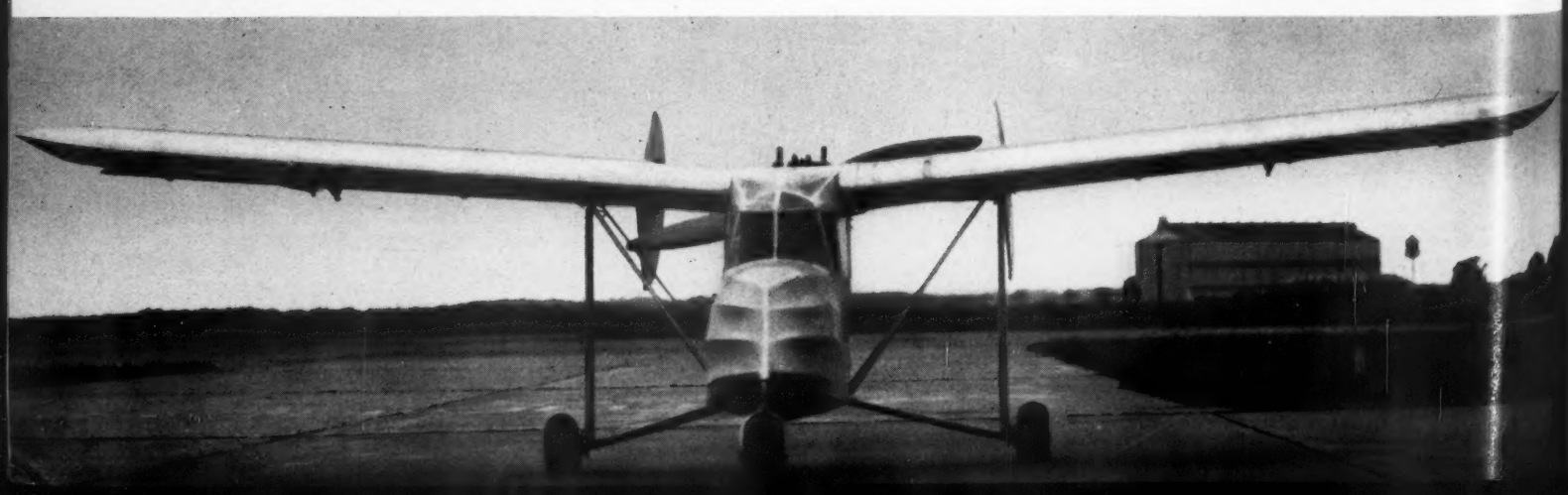
The Bureau's rudderless airplane, or more strictly speaking, the airplane in which the Bureau of Air Commerce hopes to eliminate the necessity for a rudder, is at Langley Field, Virginia, for tests by the National Advisory Committee for Aeronautics. This is the airplane designed originally by Fred Weick as an independent project, and subsequently turned over by the Bureau of Air Commerce to Fairchild's subsidiary, the Kriedner-Reisner Aircraft Corporation of Hagerstown, Maryland, for alterations including the installation of new ailerons and flaps.

The combination of slot and aileron* in the middle of the wing is designed to obviate the need of a rudder for normal turns by providing for just the right relationship between banking and turning with ailerons only. Another function of the rudder — shortening of the glide — is to be assigned to

(*Continued on page 150*)

* The slot is an opening in the forward part of the wing designed to divert the flow of air closer to the surface of the wing. The aileron is a control surface at the rear of the wing.

—*National Aeronautic Magazine*



The Weick W-1 now undergoing tests at Langley Field.

The Story of the

SOYA

— Industrial Uses of Beans

By EDWARD R. BOSSANGE, '38

FIFTY centuries ago, in 2838 B.C. to be exact, the Chinese Emperor Shen Nung, when writing in the "Ben Tsao Gang Mu", an ancient Materia Medica, mentioned an important Oriental foodstuff known as the Soya bean. Little did the sage dream at the time that five thousand years later, in a civilization new and greater than his, men would still be using the Soya bean, not only as a food, but also in hundreds of forms then unknown, such as gear-shift knobs, steering wheels, rubber substitutes, linoleum, and a multitude of other products. What is the soybean? you ask. The answer is not as simple as it might seem to be at a first glance. Outwardly the plant is an insignificant legume which for centuries has been cultivated and consumed in the Orient. Science, has however, disclosed that it is far more than a mere food. Research has made possible a new and growing industry based on this bean, has provided a new source of income for the farmer, and in its role of Aladdin has pulled out of a bean pod an amazing number of new uses for a plant whose only function for five thousand years had been to feed the mouths of the eastern world.

Although it was introduced in America in 1804 as a botanical curiosity, the soybean received no real attention until late in the 1880's when a missionary, returning from China, brought with him a bag of beans which he persuaded his brother-in-law to plant. Eventually people in various parts of the country started cultivating small amounts of soybeans, but the big step in advance was deferred until 1915, when the South suffered from a shortage of the cotton crop, and hence of cotton-seed oil. The oil that can be made from the soybean was tried as a substitute and proved to be quite successful. Ever since that time, America has been slowly awakening to the possibilities of the soya until, during the last decade, these possibilities have finally really begun to permeate the public consciousness to an appreciable extent.

In America at present about twenty varieties of soybeans are cultivated on a commercial basis. The different types of the plant vary mostly in the color and size of the seed. The yellow-seeded variety shows to the best advantage in America in the production of food, oil, and meal. Other kinds are colored green, red, black, tan, or brown, some with round and some with elliptical seeds. The stalks vary in height from six feet down to the vine-like types which grow close to the ground, while the color of the leaves is usually either fairly dark or rather pale. The plant also boasts a flower which in some varieties is white, in others purple, having either a lilac-like odor, or else none at all. In Manchuria soybeans are planted in April and harvested in September, at which time the plants are pulled out before they are quite mature in order to avoid shattering the pods. The seeds are then threshed either by trampling or by the use of a stone roller. The winnowing is accomplished by throwing the beans against the wind. Centuries of soya cultivation have shown that the bean is valuable as a crop because it builds up the soil by bringing nitrogen to it. Perhaps one reason for the soybean's long existence is the fact that it is relatively free from plant diseases and attack by insects.

The bean itself, of which there are over 2500 varieties, is valuable as a foodstuff because of its high content of protein and fat. It also contains large amounts of oil which, when extracted, may be put to a great number of uses. As a crop its adaptability to soil and climate conditions is very similar to that of corn or cotton. In China the soybean is looked upon, along with rice, as the food of the people and it is often referred to in that country as the "Meat without bones". Chinese cookbooks contain some 400 recipes making use of the soya as a human food, some of which date back as far as 3000 B.C. One of the Chinese varieties of soybean food is known as "Shoyu" which, although but few people realize it, has been incorporated into the American diet for many years in the form of soy sauce, the sauce or gravy which is used on chop suey.

Of course, as mentioned before, the uses of the soybean are not confined to application in foodstuffs alone. Of recent years Henry Ford has taken a great interest in the development of some of the industrial products of this plant. Mr. Ford is sponsoring soya research as a part of the effort that he is making to break down the barriers of both economics and production that exist today between agriculture and industry. He believes that many of the parts of an automobile, for example, can be made on the farm.

"The dinner table of the world," says Mr. Ford, "is not a sufficient outlet for the farmer's products. There must be found a wider market if the agriculture is to be all that it is competent to become. And where is that market to be found if not in industry? . . ." He continues, "I believe that industry and agriculture are natural partners. Agriculture suffers from a lack of employment for its surplus men. Industry bringing them together heals the ailments of both. I see the time coming when the farmer not only will raise raw materials for industry, but will do the initial processing on his farm."

In 1931, after a long period of extensive experimentation, Ford and his co-workers decided that the soybean would form a suitable starting point for the development of his theory. The result of this development has been that today Ford automobile owners are making almost daily use of soybean products. The Ford horn-buttons, steering-wheels, gear-shift knobs, and distributor parts all contain some products of the soya. This multifarious plant has proved its worth in a new and coming field, that of plastics.

By physical or mechanical means the soybean may be reduced to its component parts, namely the oil, the meal, and the oil meal. It is from these that the multitude of soya products are made. The oil, which is present in the bean to the extent of about 20 per cent, has only a slight odor, and is fairly palatable. Its properties are similar to those of cotton-seed oil, although it will dry more rapidly and hence is valuable in the paint industry. Since the oil contains the fat-soluble vitamins A, D, and E, the value of its food derivatives may easily be seen. The meal is nothing more than crushed or pulverized soybeans from which the oil has not yet been extracted. This meal has a rather nutty taste, and it, too, is yellow in color. Edible soya flour is prepared by removing the nutty taste by distillation. The third component, soya oil meal, is soybean meal from which the oil has been extracted.

There are three main methods of extracting the oil from soybeans. In the first, the Hydraulic Press Method, the beans are ground and cooked in steamjacketed kettles in order to make the oil more easily separable from the seed. After this preliminary treatment, the oil is forced out by the hydraulic

(*Continued on page 150*)

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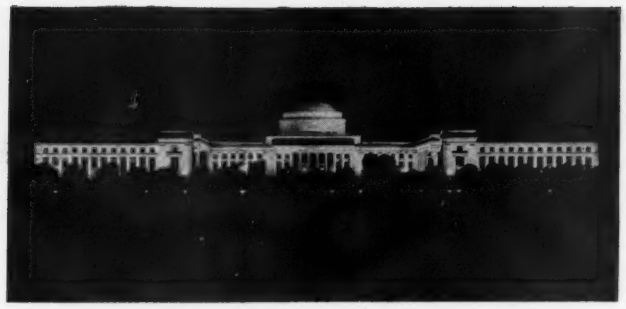


EDITORIALS

SANCTIONS

BAUXITE, manganese, tungsten, chromium, antimony —. If a hundred of the mythical "men in the street" were selected, it would be surprising if more than a few knew the nature and use of these materials in modern industry. The majority of laymen, if not all of them, do know the vital importance of many products in whose fabrication these materials play an essential part, but the names of the elements are themselves almost meaningless.

These words, and many others of a more or less similar nature, make up a large part of the list of commodities denied Italy by the sanction-imposing members of the League of Nations. Reflecting on their significance, we are once more impressed by the extent to which our whole economic structure is held together by techniques and materials of which a vast proportion of people are completely ignorant. We non-technicians may not stand quite so completely awe-struck before the modern engineer as did our gaping ancestors in the middle ages before some necromancer fumbling for an elixir of youth, but we are constantly reminded of our innocence in matters technological. Here, then, is another reminder — a great nation judged guilty of unprovoked aggression is cut off from materials of which we know next to nothing.

And yet there is a comparatively small group which does know all about these things. The men in the business of producing, using and selling these materials know — and the engineers (if they are different people) know. If it were necessary, we have further evidence in this list of banned stuffs, of the vital importance of the engineers. They are important persons!

What an important person thinks about anything is apt to be interesting, and, more often than not, of very real significance. What an important person thinks about an important problem may be of vital consequence. When the problem is in a field with which the important person is directly involved, his attitude and opinion are matters of concern to the whole world.

Whether the League or Italy is right in the present crisis which is startling everyone, the engineer has a plain duty to himself and to society — to think about and to have an opinion about the problem of international relations. It is an important problem, he is involved whether he likes it or not, and he is an important person! The solution to a considerable portion of the great general problem is the creation of an international morality. Such a morality will give to any sort of world organization a core as rigid and strong as the beautiful steels that the engineer produces so well.

The engineer controls the destiny of the world and its peoples to a degree out of all proportion to his numbers.

Almost by definition, an engineer wields some sort of authority in some field. Authority means decision and action. Action cannot but be influenced by knowledge and values. As much as any other man, and more than most men, the engineer is vitally concerned in international affairs. The sanction list merely proves it again.

Theodore Smith, *Instructor of English*

THE DISPERSION OF RESEARCH

IT is rare in M.I.T. or in any other technical university to find that the students are thoroughly familiar with the results of research, even in their own courses.

The faculty has within its reach one of the most efficient ways of acquainting the students with the developments in current research. If the members of the various departments would hold departmental meetings to discuss research publicly, a great step would be made towards its dispersion. Of what use is an university course if the graduates know next to nothing about the contemporary advances made in their field?

To learn about current progress, the student must now hunt up obscure publications in the depths of a scientific library. More often than not, the most recent research problems are not published until long after their solution has been reached. The busy student, moreover, has neither the time nor the patience to look up such publications.

The faculty, on the other hand, has easy access to the research men. The professors know what research is in progress. They receive publications from all parts of the country, and make it their business to keep abreast of the results of research in their fields. They know better than any of the students how to interpret and explain these results. They could advise the student on the applications of these findings.

If these men would meet and discuss advances, and let the student world know about them, the university courses would be far more complete, and their graduates would be more fully acquainted with recent developments than they can be at present.

LEGISLATIVE FIAT

ABRAHAM LINCOLN once stated that the best governed people were the least governed, because he saw, even in his day, the dangers of bureaucratic control of government and the constant pressure to expand its activities to offer greater reward to the politically faithful. Lincoln's statement should be given some thoughtful consideration in this day of alphabetical fancies of our government. When large sums of money are spent without careful planning and particularly in the case of political control, the inevitable spectre of corruption stalks into public view. It is axiomatic in politics that the party in power must reward its friends, this practice holding true for whatever party may be in power.

The latest law enacted by Congress concerning the public utility holding companies, is just another step in the socialistic program to bring all industry under the heel of political domination. The law forbids the holding companies to perform sales, service, or construction contract work for subsidiaries and requires that all servicing affiliations be strictly policed by the Securities and Exchange Commission. The Securities Exchange Commission is also empowered to dictate the accounting methods to be used in the various companies. The future of the holding company is rendered uncertain by the law. Theoretically, the managements of many companies must begin immediately to anticipate dismemberment.

Public utilities cannot object to reasonable control or reasonable regulation, but they must protest against the destruction of property by legislative fiat, a clear violation of the Constitution. It is the plan of the promoters of such destructive legislation to rush the bills through Congress before the general public is aware of their true content. It is therefore evident that those who are hastily pushing this legislation to a vote, are merely hiding their real intentions of destruction by the pretense that they are correcting evils of the present practice.

ON SPENDING TIME

TIME is man's most valuable commodity. He can have money, knowledge, intelligence, friends — any or all of the spiritual and material possessions which make for happiness — but if he does not have Time, he cannot make use of these possessions, and therefore gains no benefit from them. Furthermore, this valuable commodity Time is the one form of wealth that has always been equally distributed among mankind. The rich, the poor, the brilliant, and the dull share and share alike. The greatest billionaire cannot bribe Time to lengthen its hours one jot for him; Einstein himself cannot discover a method for producing a twenty-five hour day.

Yet man, frequently a hoarder of money, is usually a profligate spender of Time. Let the doubter of this statement merely compare with yesterday's sixteen waking hours the total number of hours in which he achieved something. The average student at the Institute will find that he spent about five hours in classes, four hours in actual study, and perhaps two hours in such routine actions as dressing and eating. What became of the other five hours? In most cases they cannot be accounted for. Five hours were wasted, in spite of the fact that Time is especially valuable at the Institute. A student pays nearly eight dollars a day, or fifty cents an hour, to attend; if he had a job instead of a college course, he might be earning fifty cents an hour. Therefore, each of those wasted hours was worth a dollar, or, potentially, even more. Would the average student have wasted five dollars with as little compunction as he wasted those five hours?

Most people have learned to spend money with care, while few have learned how to spend Time. When one spends a dollar, one expects to receive a dollar's worth of food, clothing, or entertainment; when one spends an hour, one should likewise expect to receive an hour's worth of experience, knowledge, happiness, or relaxation.

ENGINEERING DIGEST

—*Scientific Monthly*

A MECHANICAL SKY

THE Hayden Planetarium, New York, is one of the most recent additions to the American Museum of Natural History. Entering the great domed hall, which is the heart of the building, you are attracted to a peculiarly shaped instrument, which stands in the center of the room. This bizarre appearing mechanism, which resembles a giant dumb-bell, is the projection instrument that throws images of the heavenly bodies upon the white background of the dome. It is a collection of more than 120 stereoptican lanterns—a super "magic lantern." The lantern slides are irregular in shape, but images they throw fit closely together, so that a facsimile of the night sky is produced. The large globes at either end of the "dumb-bell" are connected by a rod, upon which the whole instrument pivots, so that any particular set of stereopticons — those presenting the stars of the northern hemisphere, say, or the Milky Way — can be turned upon the sky.

By means of this mechanism time can be turned backward or forward. That is, the heavens can be shown as they were thousands of years ago, or as they will be 12,000 years hence, for instance when Vega will have become our pole star instead of Polaris.

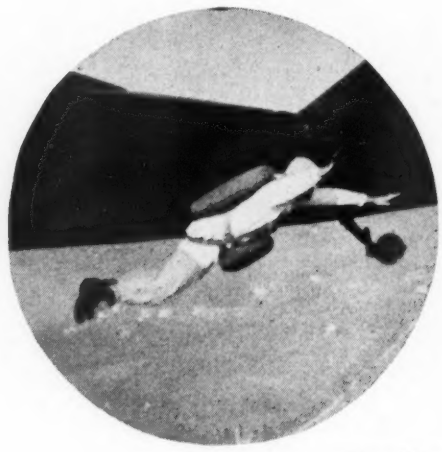
—*Natural History*

FREE FALLING

TO ascertain the subjective mental and physical reactions to a freefall in space, Captain Harry G. Armstrong, director of the Physiological Research Laboratory, Material Division, U. S. Army Air Corps, recently undertook a series of experiments. From a study of his own reactions to a 1200-foot free fall, made by means of a delayed parachute jump, he reached a number of interesting conclusions.

He first concluded that all mental reactions are normal excepting those due to fear, excitement, or other causes not directly attributable to the fall. Only one abnormal physical sensation is experienced and that consists of a very gentle, evenly distributed, superficial pressure on the downward surface of the body. Perception of an auditory nature may or may not have been impaired. Although twelve airplanes were flying in his vicinity while he was falling, Captain Armstrong does not recall hearing any of them. No sound was noticed due to the rush of air past his unprotected ears. While falling there was a tumbling motion of the body, one revolution requiring about two seconds. There was also, of course, a horizontal velocity and a downward acceleration. Of all these motions, the only one recognized was the rotation of the body. When the eyes were closed, all sensation of motion was lost, the feeling of being suspended at rest in mid-air prevailing. When the eyes were opened there was for the first time a definite sensation of falling. This lends support to the recently proposed theory that spatial relationships are determined by the eye rather than by the ear. There was no empty or "gone" feeling in the abdomen, as there is in airplanes and high-speed elevators, and the unprotected eyes were not irritated by the wind.

—*Aero Digest*



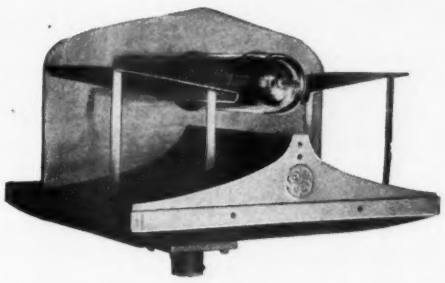
—*Aero Digest*

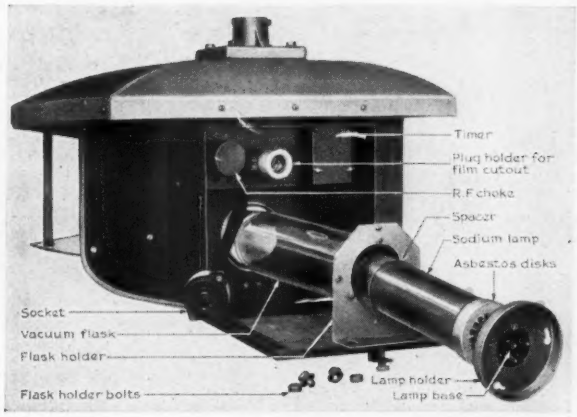
NEW SODIUM VAPOR LAMPS

SINCE the first installation of the 10,000-lumen sodium lamps in January, 1934, 400 luminaires have been so placed on highways throughout the country that almost every person has had the opportunity to observe the advantages of this monochromatic light. While retaining the same general structure of the first of these lamps, several modifications have greatly increased the advantages of sodium-vapor lighting. Slight changes in the lamp and reflectors have increased its maximum candlepower from 3050 to 3750, without altering the brightness of the luminaire noticeably. The former two-point suspension, which necessitated special brackets or mast arms, has been replaced by a single-point suspension approximately over the center of gravity. Structural changes have eliminated 150 square inches of top surface, a valuable advantage when the equipment is subjected to snow and sleet. Because of the increasing quantity of production, the gains in efficiency, and the lengthening of the lamp life, central station companies in most cases calculate rates for the 10,000-lumen sodium lighting at about half those for the 10,000-lumen incandescent unit. With the new materials and improved methods of manufacture, which are constantly resulting from research work, an even more favorable comparative cost may be looked for in the near future.

—General Electric Review

—General Electric Review





—General Electric Review

RAILROAD DEVELOPMENTS—Part A

A GLORIFIED dining car has been designed by F. A. Stiner, of the Baltimore and Ohio Railroad for the Jersey City-to-Washington run. It is divided into three parts. The conventional space for tables, each of which has four chairs, accounts for one half of the car. At the other end the designer has reserved one side of the aisle for a luxurious and novel lunch counter. The tram monel-metal kitchen is situated in between the other two divisions to facilitate service. The car is built not as a separate unit, but as an integral part of the whole train, which is entirely of modern, light weight, streamlined construction. For roominess and luxury, this air-conditioned train presents a strange contrast to the former, stuffy strings of separate cars. Comfort has taken its place along with efficiency and safety as the password of the modern railroad-car designer.

RAILROAD DEVELOPMENTS—Part B

Santa Fe has just acquired the world's most powerful Diesel locomotive. It has two power units, one of which is located at each end of the train. An operator's cab at each end of the train from which both power units may be controlled permits clear vision in front as well as on both sides of the track.

Each unit is composed of two Winton V-type 12-cylinder, high compression, two-cycle Diesel engines and develops 1800 horsepower. The engines are very light, weighing less than twenty pounds per horsepower. These power units may be operated singly or coupled to any desired number of similar units, all of which may be controlled from one cab.

The entire streamlined train of which this locomotive is a part is about 127 feet long and weighs 240 tons. It is steam heated by a special, light weight, steam generating unit which draws its fuel from the main oil tanks.

If tests are successful it will run from Chicago to California at a faster clip than the present schedule.

It is expected to reduce markedly the time of the Chicago-California run.

RESEARCH IN REVIEW

COURSE V — Chemistry

RECENTLY Professor Louis Harris of the physical chemical laboratories and Almon S. Parker, Course X, '33, have completed an investigation of the chemiluminescence of 3-aminophthalhydrazide (often called luminol but not to be confused with the drug, luminal). As long ago as 1928 it was known that the addition of oxidizing agents to a mixture of luminol and hydrogen peroxide in an alkaline solution was accompanied by the emission of a rather brilliant bluish light. Harris and Parker found that the apparent brightness of the light and the possibility of concentrating it almost at a point were conditioned by using a large excess of sodium hypochlorite as the oxidizing agent rather than potassium ferricyanide, generally employed. By building an efficient mixing apparatus it was possible to produce a brilliant spot of light not more than two millimeters in diameter. Such a "point-source" made it possible to employ a thermopile and thus obtain a more direct measure of the chemiluminescent energy than can be done with photometric methods.

In their work, Harris and Parker were interested in obtaining measurements on the quantum efficiency (quanta of light emitted per molecule of luminol introduced) and in elucidating the mechanism of the light emission. They found that the chemiluminescence extended from the violet far into the red end of the spectrum and that the quantum efficiency, while only 0.3%, was about 10,000 times greater than any thus far reported for similar cases.

It was shown that the emission of light energy changed with alterations in the concentration of hydrogen peroxide, indicating that it plays an important role in the chemiluminescence. The evidence pointed to an association of four molecules of peroxide with each mol of luminol. Hydrogen peroxide had a similar effect on the absorption spectra and the fluoresence of aqueous alkaline solutions of luminol increased when hydrogen peroxide was added.

It seems fairly definitely established that luminol (or its sodium salt) combined with hydrogen peroxide is the true light-emitting molecule and that the added oxidizing agent brings this molecule to its energized state where it gives off light.

COURSE XII — Geology

PROFESSOR NEWHOUSE has recently completed an important investigation in a new field, that of the opaque minerals in igneous rocks. New data were obtained on the oxide and sulphide minerals which are widely dispersed in these rocks. The new information has an important bearing on the present-day theories of magmatic differentiation, and on the formation of certain types of ore deposits.

Recent publications by graduate students in geophysics at M.I.T. include the first study of crustal discontinuities by internally reflected seismic waves. The source of the waves was a deep earthquake occurring about 400 kms. below the surface. The M.I.T. differential analyzer was used for the direct determination of ground motions from the seismograph records. The study appears to afford preliminary evidence for the existence of a relatively sharp discontinuity at a depth of about 32 kms.

Dr. N. A. Haskell published an interesting estimate of the viscosity of crustal rocks. The deductions were based upon the solution of the viscous flow problem for a half space under a concentrated load, and upon geological data concerning the changes of level caused by plastic recoil of the crust after the melting of the ice cap of the recent glacial era. The viscosity for the crustal rocks so obtained is exceedingly high and comparable to that of steel.

Because of the importance of crystal structure models both in crystallographic research and teaching, a new instrument to facilitate the making of these models has been constructed. X-ray crystallographic studies by Professor Buerger have resulted in the determination of the crystal structures of the minerals berthierite ($FeSb_2S_4$), cubanite ($CuFe_2S_3$) and valentinite (Sb_2O_3). Anomolous diffraction effects in arsenopyrite (FeAsS) have lead to an investigation of a possible ordered-disordered transformation in this mineral accompanied by a symmetry change. These effects have now been discovered and this new information will permit a definite deduction of the crystal structures of the arsenopyrite group of minerals which, to date, have given inexplicable diffraction effects.

The polymorphism program, under the general direction of Professor Buerger, has been facilitated by a grant from the Rockefeller Fund. Mr. Bloom, research associate, engaged in investigating the chemical aspects of this program, has partially completed the investigation of the antimony trioxides. Mr. Schulman is carrying on a study of the mercury sulphides under Mr. Bloom's immediate supervision, with encouraging results.

Professor Frederick K. Morris completed a paper on "Central Asia in Cretaceous Time" as one of the final reports on the Central Asiatic expeditions. He published an essay on "Time and our ways of thinking", analyzing the effects which the new time scale has wrought in the fundamental theories of geology. A short book on the Hudson River Valley is now in press. He continued the structural studies of shales, slates, and phyllites of the Narragansett Basin, and cooperated with students in detailed studies of the geology of eastern Massachusetts.

COURSE VI — Electrical Engineering

THE Differential Analyzer in the Electrical Engineering Department has now been in operation for about five years. Its value has been demonstrated repeatedly in a series of important problems involving many fields of science and engineering, and since it began operation three machines modeled after it have been placed in operation elsewhere, another is under construction, and still another is projected.

Last July an M.I.T. group under the supervision of Dean Bush began work on the development and design of an improved machine, based on the same fundamentals but radically different in concept and design. Progress thus far has been encouraging, and it is expected that a faster and more precise machine of enlarged range will ultimately result from this work.

COURSE XVI — Aeronautical Engineering

THE field of aircraft instruments is peculiar in that it groups together devices which use a wide variety of physical principles and have in common only the fact that each is useful in flight operations. To facilitate the coordination of these principles, an aircraft instrument laboratory has recently been started, which is under the direction of Professor C. S. Draper. The work of this laboratory is really applied physics which starts with the dynamic behaviour of mechanical systems and finally treats the application of electromagnetic theory to aircraft communications. In every case the predictions of theory are compared with experimental results obtained either in the newly established instrument

laboratory or in actual flight.

To be completely satisfactory an instrument should be a system with one degree of freedom; that is, each position of the indicating element must correspond to only one value of the quantity to be measured. In addition the reading should be correct at each instant no matter how rapidly changes are taking place in the actuating force. With the present development of the instrument-makers art, it is possible to produce indicators whose performance will be practically perfect under static or slowly changing conditions. With modern high speed aircraft, however, the response of an instrument to rapidly changing conditions becomes important and it is necessary to study the dynamic characteristics of instruments as distinct from their static calibration.

The dynamic performance of an aircraft instrument can be predicted under any arbitrary conditions if three quantities, a "mass coefficient", a "damping coefficient", and an "elastic coefficient" are known. In general these coefficients can be treated as constant only over a limited range, but the theoretical results agree well enough with observations for the general sceheme to be very useful in determining dynamic errors and for showing the possibility of improvements in a given instrument.

It is not always easy to calculate dynamic coefficients from the instrument itself, so the usual procedure is to determine effective values and to find the operating range over which the theory may be applied by actual experiment. Therefore the equipment of the Technology Instrument Laboratory is designed to study the response of each instrument type to a controlled actuating force.

In the laboratory, the coefficients for an aircraft magnetic compass are determined by means of a "compass analyser" which makes it possible to control the magnitude and direction of field which acts on the card and also to produce an arbitrary motion of the case which contains the damping liquid. The compass is an especially complicated case so provision has been made for measuring the dynamic coefficients over a wide range of conditions. The gyroscopic instruments are studied with the aid of a machine which simulates the conditions existing in an airplane turn. A closed chamber with a cam operated piston makes it possible to study the behaviour of pressure operated instruments such as the altimeter or airspeed meter. By properly shaping the cam, and controlling the average pressure in the chamber, it is possible to subject an instrument to the changes which occur during an arbitrary airplane maneuver performed at any altitude. The effect of vibration on any instrument can be found by use of a machine which produces a sinusoidal vibration in one direction. By changing the amplitude and frequency of the motion it is possible to find the "resonance curve" for any particular instrument and so to locate the source of vibration troubles.

At the present time the laboratory equipment is rapidly being extended to include other apparatus for studying current instrument problems. It is hoped that a policy of close cooperation between the Institute and manufacturers of aircraft instruments will produce many results of mutual benefit.

COURSE VII — Biology and Public Health

ALTHOUGH none of the departmental research projects for the first term have been completed as yet, certain investigations carried over from the summer are worth mention. The conclusion of an investigation of several years duration was reached when Harris and Bunker reported to the Spectroscopy conference that the wave lengths of light which are of value in curing rickets are within the limits 2537 and 3130 Angstroms. During the summer Dr. P. K. Bates ('24) undertook with Dean Prescott, a technical investigation of food refrigeration in ice boxes vs. iceless refrigerators. Thesis work looking to a controllable transformation from one species of bacterium to another is under way. An intensive investigation of germicides is going along. The study of how to stabilize an active chemical compound, discovered in the department of organic chemistry, and established in our laboratories as being specifically potent in combatting the fungus disease commonly called Athlete's Foot, is progressing. Dr. Williams has published exhaustive studies on the cultural characteristics and behavior of the particular fungi involved. Wierd and ingenious apparatus has been designed and put in operation for catching and identifying the last essence of the aroma and flavor constituents of coffee. A study has been made of the effect of ionized silver upon the prevention of microbal attacks on trout. So also the protection of textile fibers against mildew and other microbic ills is progressing. Preliminary studies on the content of dusty and germ-laden atmospheres will contribute to the forthcoming Institute study of air purification. Professor Turner, on leave of absence, is gathering first hand information on health education in Russia, Europe, Asia, and Australia, and at ast writing was hurrying to get through the Red Sea before the Suez Canal was closed.

COURSE II — Mechanical Engineering

IN addition to the experimental program which is under way to measure the discharge coefficients of metering nozzles, Professor Keenan of the Mechanical Engineering department has begun experiments on the development of steam tables. The project is a joint enterprise between Professor Keenan and Dr. Keyes. An equation of state for the computations has recently been developed by Professor Keenan. The research does not extend to the formulation of the properties of steam above the critical point where liquid and vapor are indistinguishable, for the equation of state does not cover these cases.

For over a year now there has been a continuous humming in the basement of the south wing of Building 2. There Professor Buckingham is supervising tests on surface failure due to rolling contact. For the first time, the behavior of rolling stock under various loads and speeds is rising out of the guesswork stage. Disks of various materials such as cast iron, under different conditions of hardness and composition, are rolled against a hardened ground roller of steel, in a machine consisting essentially of a dynamometer, a system of gears to control the sliding of the disks, if any, a graduated spring to control load, and a lubrication system to insure satisfactory and constant friction conditions.

The cam roller which is now on the machine, and against which the test specimens are rolled, has shown no signs of wear after approximately 150,000,000 revolutions under load. From the 45 tests that have been made on cast irons, and the many made on brass, bronze, textilite, and other materials in connection with thesis work, it has been shown that there are three main types of surface failure. The first type, pitting of the surface, appears in almost all the tests at various times, when small pits which can be clearly seen under a low-power microscope or even by the naked eye, appear on the surface of the specimen. On soft surfaces, these pits later develop into large flakes which come off, giving the surface the appearance of mice-ridden cheese. On harder surfaces, the wear appears as waves of plastic flow, much as if the surface had been cold-worked. On hard surfaces, the ultimate service failure, when the sample is worth nothing commercially, comes in the shape of flakes forming in blisters of a thickness depending on the depths of greatest strain of the material.

It is for the first time that this field is being explored, and several companies and socieites, such as the A.S.M.E., and the United Shoe Company, are greatly interested in the results.

PRIVATE AIRPLANES

(*Continued from page 142*)

the flaps. The third function of the rudder is a conventional design does not apply in the Weick since it has a three-wheeled landing gear making cross-wind landings possible without a rudder.

A low-wing, all-metal two-place cabin monoplane, was ordered from the Curtiss-Wright Airplane Company of Robertson, Missouri, to furnish information on the possibilities of all-metal construction for private craft. The work on this airplane has proceeded rapidly and satisfactorily, and it has just been delivered to the Bureau.

Turning to the power plant projects, all aimed primarily at cost reduction, the first was for solid steel propellers suitable for the Hammond airplane. Tests already made indicate that the propellers ordered from Ernest G. McCauley of Dayton, Ohio, will be slightly more efficient than older types, and there is a prospect that they will bring about an improvement in cooling of the engine. The cost reduction element is introduced by machining blades and hubs from die forgings, thus lessening costs after shop machinery has been set up. The first of the propellers is on its way to the Bureau as this is written.

The other power plant projects are concerned with the adaptation of automobile engines to aviation purposes, except one which is the reverse. The advantage of using an automobile engine as an airplane power plant arises from the fact that these engines are volume-produced and can be purchased for about $150 each. An aviation engine of similar power costs about $1,000.

The Bureau has contracted with the Arrow Aircraft and Motor Corporation of Lincoln, Nebraska, for an airplane powered with a Ford automobile engine. Although gears are required to permit the propeller to turn at its most efficient speed, and some adjustments have to be made in the engine to mount it in the airplane, the changes are not numerous, and regular automobile engine parts can be used almost invariably when replacements become necessary. The engine has been tested by the Bureau and granted an approved type certificate for use as an aviation engine.

The airplane, soon to be delivered to the Bureau, is a low-wing monoplane with side by side seats in an open cockpit.

In Newark, the Casey Jones School of Aeronautics has concluded a test, on the ground, of a V-belt drive connecting a Terraplane engine with a propeller. The engine so set up was run in a 300-hour endurance test. In the test, a complete report on which was published in the *Air Commerce Bulletin*, September 15, 1935, the belt drive functioned satisfactorily. If the belt drive proves to be satisfactory for use in airplanes, it will provide a cheap and relatively light reduction gear for use in automobile-engined airplanes and will permit more latitude in choice of engine location within the airplane structure. The high speed of operation of automobile engines makes some form of reduction gear necessary to permit a slower propeller speed.

The third engine project consists of a 90-horsepower, 6-cylinder, radial air-cooled airplane engine, plans for which were presented by the Continental Motors Corporation. The engine will be only 20 inches in diameter, and will operate on the 2-stroke cycle, which gives a power impulse from each cylinder every revolution in contrast to the popular 4-stroke cycle engine which gives a power impulse for each cylinder every other revolution. The 6-cylinder engine therefore will have as many explosions per revolution as a 12-cylinder 4-stroke cycle engine. Following automobile practice, the engine will be operated at a high speed.

This engine appears to have possibilities as one which can be adapted from aviation to automobile use. The adaptation of an engine designed for automobile use to aviation use probably offers the greatest opportunity for reduction in power plant costs, but part of the savings are lost in the additional cost of the airplane due to greater dead weight. The adaptation of an engine designed originally for airplane use to the purposes of the automobile offers less possibility of reduction of power plant costs, but may possibly result in a lower total cost due to the savings in power plant weight.

The Continental Motors Corporation personnel is working day and night on this project. Single-cylinder test engines have been built and tested as have other units of the design,

Costs reductions, as sought in the power plant projects, and improvement of airplanes toward the goal of simplicity. safety, and comfort should set the stage for an increased popularity of private flying.

A possible clue to the future may be found by reflecting upon air line development in the past few years. The air lines have increased flying speeds on many schedules from around 100 miles an hour to a level somewhere between 150 and 180 miles an hour. They have improved sound insulating methods so that the cabins are much less noisy than in the past. They have scheduled more planes per day on many routes and are carrying passengers at night. On some of the night schedules airplanes with berths are available. They have lowered fares from 12 cents in 1929 to 6 cents a mile now. In other words, the scheduled air transport companies, over a period of several years in the immediate past, have sought diligently to improve their service and make it attractive to travelers. Their efforts are being rewarded this year by record-breaking passenger loads. In August the air lines flew more miles and carried more passengers than in any previous month in their history.

Comparable efforts to provide something attractive for those who are potential private owners should have a similar result. With real improvements in airplane design and reduction of private flying costs, there ought to be some record breaking in that phase of aeronautics.

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SOY BEANS

(*Continued from page 143*)

presses. A similar method has been used for hundreds of years by the Chinese who use wedge presses instead of the more modern hydraulic form, although in some parts of the Orient stone hydraulic presses are used.

The second process is the Anderson Expeller method. Here the preliminary treatment involves crushing the beans and reducing them to a low moisture content. They are then cooked in the same kind of kettles as those used in the hydraulic press systems. Finally, the crushed seeds are led to the expeller which acts on the principle of a meat grinder, extracting the oil by friction.

The Solvent Extraction System, which is a more recent development, removes a higher percentage of the oil. The preparation consists of cleaning and rolling the beans, after which the flaked seeds are treated with the solvent, usually benzol, naphtha, or ether, which dissolves out the oil. In the last step the oil is distilled from the solvent, which is used over again.

The preparations of a few of the better known soybean products are interesting. Aside from the extraction of the oil — the basic process — soya is treated in numerous special ways for the production of its various derivatives. Among the more interesting of the special processes is the traditional method of preparing Shoyu, a Chinese food, which has been mentioned before, by a fermentation process. The flavor depends upon two factors, namely the method of brewing and the length of time the brew is left to ripen. Fermentation and ripening are done in Korea in jars which are left in the sunshine by day and covered at night for a period of from a few months to a few years.

Soybean milk is made by soaking the dried beans in order to soften them, and then crushing them in a meat grinder. Following this the beans are boiled for about an hour in three times their volume of water. The milk is then strained off through a cloth.

Soya cheese can be made by adding hot soybean milk to a solution (approximately 1%) of Calcium or Magnesium salts. A greyish-white precipitate or curd of the proteid substances settles out leaving a yellowish liquid. The curd is then drained and pressed. This bean curd, or Tofu, as it is called, is extensively eaten and forms the basis of numerous fermented, smoked, and dried cheeses consumed in China and Japan.

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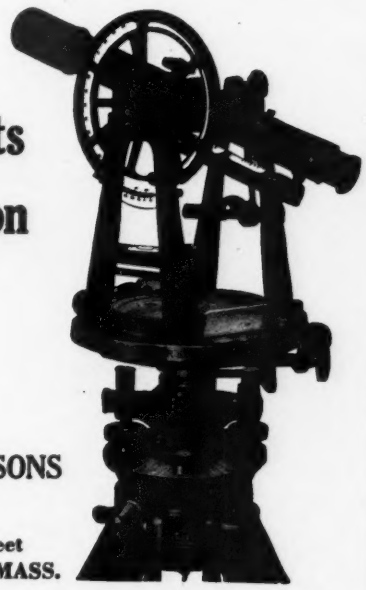

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As a human food, the soya is found in certain kinds of bread and pastry, and the beans themselves are canned and sold as such. The value of these beans as a human nutrient may best be shown by a few examples. The famously strong Chinese coolies live mainly on a diet consisting of soybeans and rice. Oriental babies, if deprived of breast feeding, are given soya milk and other foods made from this plant. The Buddhist priests, whose religion does not allow them to eat meat, obtain their proteins from Tofu and similar soybean foodstuffs.

Soybean milk, to which vanillin is sometimes added for flavor, is good for children. Cakes, custards, curds, and cheese made from this milk are consumed in great quantities in the Orient, but, as yet America has not acquired a taste for them. Recently some manufacturers of ice cream have found that 1 per cent of soy flour added to their products will impart smoothness, taste, and keeping qualities. This flour is also used in macaroni, spaghetti, noodles, vermicelli and doughnuts.

Another product of the multifarious soybean is known as lecithin, a phospholipoid which is present in the seed to an extent of 1.65 per cent. It is extracted from the bean at the same time as the oil in the Solvent Extraction system, and they have to be separated by a special process. Commercial lecithin is either a dark, brownish-colored paste, or else a very viscous, heavy fluid. This product finds its use in several fields. Because of its action on fats as a protective colloid, lecithin is used in large amounts in the margarine industry, as it binds the water in the substance and therefore prevents spitting when used in frying. Lecithin is also used by chocolate makers to give their products gloss. The textile industry absorbs a considerable amount of lecithin to give cotton and woolen goods a soft, supple finish. This same derivative will prevent gumdrops from hardening and will also reduce the viscosity of cocoa.

The soybean product which is now in greatest demand is the oil. It is now used in certain kinds of paint in place of linseed oil. Paint manufacturers turn the oil into resin and use it as a base for enamel. In paint, soya oil will increase the toughness of the coat and prevent white and enamel paint from turning yellow. The amount of this oil used in paint varies from 10 to 25 per cent. Artificial resins containing soybean oil or fatty acids from soybean oil are extensively used in this country.

A complete list of the uses to which the oil is put would be too long to give here. A few of them, however, are quite interesting. Soybean oil is used for cores in butter and lard substitutes, explosives, linoleum and varnish. The lard substitutes are a mixture of lard with partly hydrogenated soya oil. One of the most important uses to which the oil is put is in the soap industry. Today over one dozen soap manufacturers are making use of this oil.

Industrially the plant finds its way into printing inks, candles, water-proofing, linoleum, core-binder, and rubber substitute. These are but a few of a multitude of uses covering many fields, the scope of which is constantly being widened as the interest in and demand for soybean products steadily grows.

An interesting, and possibly very significant, development of the economic importance of the soybean has recently been brought to light in connection with the lubricating oil and gasoline industry. Japan, because of her lack of petroleum, imports practically all of her oil and gas from the United States. The Japanese Government has recently been conducting a series of experiments with soybean lubricating oil and gasoline. A simple explanation of the production of soya motor oil and gasoline is given by Dr. A. A. Horvath of the Agricultural Experiment Station of the University of Delaware. "To a chemist, gasoline is a hydrocarbon. Soybean oil is a hydrocarbon plus oxygen. If you can take the oxygen out you have a sort of petroleum which you can distill into lubricating oil or gasoline, just as you would the oil from a California well."

In America soybean oil is sold in competition with such products as cottonseed and linseed oil, flaxseed oil, and whale oil. For this reasou the oil is not used in as large quantities as it might be if there were fewer competitors. In the paint industry, paints using soya oil cost about one cent less per pound than linseed oil paints.

Many people have asked why it is that the soybean, applicable as it is to so many fields, has not yet reached the stage of universal consumption and recognition as has such a plant as, for example, the potato. And yet it took the latter vegetable over 300 years, following its introduction into Europe, to become universally used. The soybean, however, is at most 100 years old in America and already it shows signs of becoming one of the most important factors in the bridging of the slowly closing gap between industry and agriculture. As a food, a fertilizer, a plastic, and as a base substance for numerous other important products, such as paint, rubber-substitute, and soap, the soybean is coming into agricultural and industrial prominence on a slow but none the less sure and steadily increasing scale. When the advantage of this plant as a stockfeed alone is realized, there will be an almost unlimited demand for it in this field. Farmers are swinging towards the use of the soya because the soil on which it grows becomes more valuable for raising crops. In America as everywhere else, the soybean offers possibilities for the establishment and entrenchment of several new industries. Just as industry and agriculture increase in magnitude and tend toward a future unity, so also is there the definite possibility that the final knot may be tied by a little bean, a fifty-century old Oriental foodstuff which today is commanding attention everywhere because of the services that it can render mankind — the soybean.

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G-E *Campus News*

EDITORIAL BOUQUET

IT IS very pleasant to have people say nice things about one. The pleasure is curiously heightened, however, when the nice things are said in a roundabout way—never intended directly to reach one's ears. General Electric recently was honored in such a manner on the editorial page of the Spokane, Washington, *Chronicle*, and the Company is still basking in the warmth of the glow generated. The editorial, in part, read as follows:

"An exposition at which inventors of the Pacific Northwest will display their work will be held next month in Portland.

"It will probably be a revelation to those who see it. Most persons find it hard to think of great men coming from 'near at home.' When one speaks of inventors or scientists, the Northwest citizen thinks of the General Electric laboratories, or of observatories in California, or clinics in Vienna. . . ."

CELESTIAL PUSH-BUTTON CONTROL

HEAVENLY bodies a million times fainter than the faintest star the eye can see unaided will be brought to the earth for inspection and photography at the touch of an electric push button when the McDonald Observatory on Mt. Locke in western Texas is placed in operation. The observatory building itself is almost completed, but the technicians of the Warner and Swasey Company at Cleveland are "making haste slowly" with the polishing of the 82-inch reflecting mirror. They estimate that another 12 or 18 months will be needed before the mirror is ready for installation. The 45 tons of moving parts of the telescope will be at the command of a single individual, who will be able to take his stand upon an observing bridge and virtually order the stars to parade before him. The motors and complete electrical control to make this possible have been manufactured for the builders of the telescope by General Electric.

VOICES FROM THE SKY

WHEN the Whiteface Memorial Highway—a road leading to the summit of the 5000-foot Whiteface mountain in the heart of the Adirondacks—was dedicated this autumn, voices came down from the sky on a beam of light. There was nothing mystical about this performance, however. The beam of light came from a 24-inch G-E searchlight on the summit of the mountain. The voices were those of President Franklin Roosevelt and New York's Governor Herbert Lehman.

President Roosevelt's words, dedicating the highway, were carried on the light beam seven miles from the mountain to the crowd at the Lake Placid airport. Governor Lehman had spoken over the light beam the night before. He was so interested that, after the dedication ceremonies were finished, he spoke again to demonstrate the equipment to the members of his family. Both night and day demonstrations were successful, although once or twice during the day the words faded to faintness when small clouds floated by the mountain top and partially obscured the light beam.

Two-way communication was carried on by means of short-wave radio equipment located at the airport. G-E engineers, who made this special installation, had to transport a gas-driven power plant and a dozen or more storage batteries to the mountain top to operate the talking light beam.

96-205DH

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